ACCESSIBILITY DIFFERENCE IN EDUCATION-RELATED WEBSITES FROM DEVELOPING AND DEVELOPED COUNTRIES

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Abstract *– In recent years, websites have become the key source of information for most people. There are several websites related to education, healthcare, government, e-commerce, and so on. These websites are used by a large population to access required information. Web content must meet the accessibility guidelines for websites to be accessible to all users, including people with different ranges of abilities across the globe. Thus, accessibility of the web is the prime facet of every website. This paper focuses on identifying accessibility differences in education boards or similar websites anchoring higher-level schools' leaving examinations. We have considered evaluating the accessibility of landing pages of 13 educational websites from a developing and developed group of countries. Six Web Content Accessibility Guidelines (WCAG) tools from the World Wide Web Consortium (W3C) were considered for evaluating each website. We have tabulated the results of each tool, highlighted the different accessibility issues for each website, and provided alternate suggestions that web developers can consider for resolve any issues. From the results we noted that the developing group of countries reported the maximum number of accessibility issues when compared to the developed group of countries. Selected webpages of developing and developed countries identified text contrast failures, and non-text contrast failures respectively. The education board websites of India and Japan were identified as having the maximum number of accessibility issues when compared to other selected websites.*

Keywords – Developed and developing countries, educational board websites, web accessibility, web accessibility evaluation tools, Web Content Accessibility Guidelines (WCAG), World Wide Web Consortium (W3C)

1. INTRODUCTION

With the emergence of the Internet, most offline platforms have shifted to online platforms. With just a click on a webpage, people can access information from all around the world. According to siteefy [1], a website about digital marketing and Search Engine Optimization (SEO) services, there are about 1.13 billion websites in the world, among which 18% of them are being actively used by people across the globe. Each country maintains multiple websites enabling their citizens and residents to access different services easily and efficiently without the usual problems such as long queues, time, and effort, and so on [2]. However, it is important to make the webpages accessible to a majority of people, including those with different ranges of abilities to secure equal access and opportunities for every individual. Tim Berners-Lee, the father of the World Wide Web (WWW) stated that "The power of the Web is in its universality. Access by everyone regardless of disability is an essential aspect" [3].

Therefore, the web should be fundamentally designed to work for all people independent of their abilities. So, accessibility is an essential aspect to be focused on by web designers and developers. Web accessibility means that websites, tools, and technologies are designed and developed so that people with disabilities can use them [3]. As more accessible websites and software become available, people with different ranges of abilities can use and contribute to the web more effectively. According to Web Accessibility In Mind (WebAIM), 96.3% of homepages had detected Web Content Accessibility Guidelines (WCAG 2) failures while evaluating the accessibility of homepages for the top 1 000 000 websites [4]. Similarly, it was reported that over 90% of websites in the UK are inaccessible, thus creating a barrier to finding jobs online for people with varying abilities [5]. Thus, the accessibility of information provided on websites is foremost so that it can be easily accessible by every group of users.

Regarding education, a website plays a significant role in providing vital information to its intended users. School-related websites play a crucial part in imparting various information to a wide range of students, parents, teachers, and so on [6]. While accessing education-related websites, users may face problems because of their varying extent of abilities, such as color blindness, hearing impairment, short-sightedness, and so on [7]. So, the primary concern when it comes to educational websites is the accessibility of the information they provide. There are multiple types of school-related websites; for example, some websites provide only information related to a particular school, and some websites provide universal information to their users, which is common among all schools. Websites containing universal information for their users are mainly related to examinations which are conducted at a high level. Such exams are mainly high school leaving exams or board exams. Board examinations hold an indispensable place in a student's life, helping them in deciding their careers. Examinations are usually conducted at school level for secondary and senior secondary, and college level for higher education (Fig. 1). To enroll in higher education, a student must take up the board/final examination and qualify to complete their school-level education. Each year, several students enroll in the board examinations (or final year school examinations) all over the country, and each country has their own education boards conducting their own examinations. Information of the education boards are presented through websites helping students, teachers and parents to enroll and register for examinations, and also to access timetables, curriculum, syllabus, results, etc. It is important that these websites are evaluated for accessibility in order for them to be accessible for everyone.

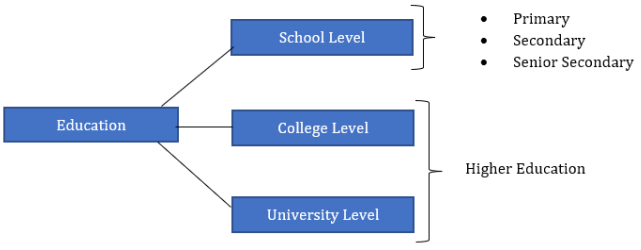

Fig. 1 – Education levels

However, we may note that it is strenuous and time-consuming to evaluate accessibility of all education board-related websites across the world. Thus, we considered focusing on selecting websites that belong to some developing and developed countries. Specifically, in this paper, we focus on evaluating the accessibility of secondary education board-related websites for the BRICS (Brazil, Russia, India, China, and South Africa) and G7 (Canada, France, Germany, Italy, Japan, the United States, and the United Kingdom) group of countries (Table 1). Each of the education board website are evaluated using six web accessibility evaluation tools [8] namely Access Assistant Community Edition, Button Contrast Checker, Siteimprove Accessibility Checker, TAW, Utilitia Validator and WAVE. The tools are selected based on Web Content Accessibility Guidelines (WCAG) guidelines, Perceivable, Operable, Understandable and Robust (POUR) factors, levels of conformance, language, types of automatic checks, supported formats, and so on.

Table 1 – Selected group of countries

Developing	Developed
BRICS	***G7***
Brazil	Canada
Russia	France
India	Germany
China	Italy
South Africa	Japan
	UK
	US

The rest of the paper is organized as follows: Section 2 presents a literature study of the existing work related to accessibility evaluation of education-related websites, Section 3 lists the details of the strategies followed for the selection of websites and accessibility evaluation tools, Section 4 presents the results obtained from the accessibility evaluation of the selected websites, and this is followed by concluding remarks in Section 5.

2. LITERATURE REVIEW

To make the web universally accessible, the Web Accessibility Initiative (WAI) developed web accessibility guidelines, technical specifications, and educational resources [9]. There are specified rules and regulations in different countries to make their websites accessible to a varying range of users. For example, in the USA, the Americans with Disabilities Act (ADA) [10] and Section 508 of the Rehabilitation Act [11] laws ensure that all state and local governments, educational, and business websites open to the public are accessible to people with disabilities. In India, the Guidelines for Indian

Government Websites (GIGW) recommends that web applications follow the WCAG guidelines in order for the webpages to be used by the widest possible audience [12]. In the UK, there are multiple acts which deal with conformance of accessibility guidelines by the education websites, such as the Equality Act 2010 , Public Sector Bodies (Websites and Mobile Applications) (No. 2) Accessibility Regulations 2018, and so on [13]. Despite the various acts, rules, and regulations, there still exists multiple accessibility issues in education websites, that restrict many users from accessing them. This section briefly summarizes the past work corresponding to accessibility evaluation of education-related websites done so far. We have tabulated a few insights gained from the review of previous work regarding accessibility evaluation of education-related websites in Table 2.

Jati and Dominic [14] evaluated accessibility of randomly selected 90 government, education, and business websites of Malaysia using the Tawdish tool. They classified the identified accessibility errors based on three priority levels. Results noted that 93%, 87%, and 87% of education, government, and business websites contained error priority level 1. The rest of the websites contained error priority levels 2 and 3. In another similar study, Ismail and Kuppusamy [15] evaluated 40 websites including education, health, e-government, etc., websites of North Eastern regions of India. They provided analysis reports using tools, namely, EvalAccess and WAVE. It was found that the priority level 1 errors were less; however, there were a large number of accessibility violation warnings. They recommended that web accessibility awareness programs on web content accessibility guidelines should be provided to web designers and developers. A paper by Nishtha and Sanjay [16] evaluated accessibility of top universities and educational institutions websites of countries like UK, Russia, China, Germany, and India. The selection of countries was an intermix of developing and developed nations. The evaluation used TAW, HERA, and Firefox Accessibility Evaluation Toolbar tools. The results were presented in the graphical form highlighting pass and fail criteria according to WCAG 2.0 of each country's website. Results from the evaluation noted that most of the selected websites followed less than 50% of the WCAG guidelines. Kous et al. [17] evaluated the entry webpage of 17 faculty websites at the University of Maribor using the Web Accessibility Checker tool. The authors aimed to examine the WCAG 2.0 compliance level of faculties' websites, in between 2018 and 2019. The study presented a comparative analysis of the websites between the mentioned years, and noted that in 2019, websites had more accessibility issues than in 2018. Authors also recommended suggestions based on the issues found. Vishal and Hardip [18] evaluated 27 university websites of Punjab, India, using TAW and WAVE tools. They aimed to examine problems that were occurring multiple times and identify users who were affected by such problems. A large number of perceivable errors were identified for A level of conformance. Suggestions were also recommended by authors based on the results. Recently, an approach called variable magnitude was presented by Kuppusamy and Balaji [19]. The authors aimed to compute the accessibility of the homepages of the top 25 Indian institution websites for persons with disabilities. A variable magnitude approach was proposed to compute the barrier count of a webpage. AChecker and WAVE tools were used to give the scores to compute the barrier count based on evaluation components. Recommendations were listed based on results and feedback from students with disabilities. A paper by Ismail et al. [20] presented accessibility analysis of 59 higher education websites, 19 websites of polytechnics and 40 websites of universities of Portugal. The work aimed to provide feedback and suggestions to website developers and designers on making webpages universally accessible. Tools like Achecker, WAVE, and aXe were selected for accessibility evaluation of the websites. Results from the analysis noted that major violations were in alternate text for images and buttons, image contrasts, and links without visible text. More recently, Alhadreti [21] used four tools, namely AChecker, WAVE, PageSpeed Insights, and Similarweb, to evaluate landing pages of fifty-eight higher education websites of the Kingdom of Saudi Arabia from public and private sectors. The paper's objective was to evaluate the current state of accessibility, performance, and engagement of higher education institution websites. Results showed that only four public institution websites and only one private institution website had no errors and were completely accessible to their users. In a recent case study by Ismail and Kuppusamy [22], 44 college websites were investigated, and major accessibility issues were identified using TAW and aXe tools. Authors listed the major accessibility barriers reported by websites in terms of several identified problems, warnings, and success criteria violations. The evaluation noted

that color contrast, alternative texts, lang attributes, link availability, marquee elements, etc., were the major issues identified among the websites. Based on the results, suggestions were listed to overcome the accessibility issues. Sophia [23] explored the accessibility of homepages of UK research-intensive universities using TAW, WAVE, and Ell Page Checker tools. It was noticed that the most common violations among all the webpages were contrast errors, missing form labels, empty links and headings, etc. Also, on comparing the web accessibility results with similar studies in other countries, UK-selected webpages performed well. Shawar [24] evaluated the university websites of Jordan, UK, and the Arabic region to measure their compliance with accessibility standards for visually impaired people. For the evaluation of websites, WAVE and Cynthia tools were used. It was observed that accessibility errors of websites in Jordan and the Arabic region exceeded the ones in the UK by thirteen times and five times, respectively.

From Table 2, we observed that most existing literature focused on evaluating higher education websites either for a particular country [14] [15] [19] [20] [23] or for a specific state [18] [22] using a minimum of one [14] [17] to four web accessibility tools [21] [25]. Also, we found that, in very few literature, websites were selected from multiple groups of countries [16] [24] or from various sectors [21]. We noted that assessing the accessibility of school-related websites had not been done before. To the best of our knowledge, this is the first study to evaluate the accessibility of education board-related websites where the selection of websites is based on a specific group of developing and developed countries.

Table 2 – Summary of existing literature on accessibility evaluation of websites

Year	Website type	Number of websites evaluated	Tools used
2023 [21]	Higher education	59	AChecker, WAVE, PageSpeed Insights, and Similarweb
2023 [19]	Higher education	25	AChecker and WAVE
2022 [22]	Higher education	44	TAW and aXe
2021 [18]	University	27	TAW and WAVE
2021 [23]	University	66	TAW, WAVE, and Ell Page Checker
2020 [20]	Higher education	59	Achecker, WAVE, and aXe
2019 [17]	Faculty website	17	Web Accessibility Checker
2016 [16]	Higher education	50	HERA, TAW, Firefox Accessibility Evaluation Toolbar
2016 [15]	Education, health and e-government	40	EvalAccess and WAVE
2015 [24]	University	18	WAVE and Cynthia
2008 [14]	Government, education and business websites	90	TAW
2007 [25]	University	100	Bobby, Cynthia, FAE, and WebInSight

3. SELECTION OF WEBSITES AND ACCESSIBILITY EVALUATION TOOLS

3.1 Selection of websites

Different countries conduct board examinations in different ways and at different levels. Some countries like India, Canada [26] [27] have a separate body to conduct board exams. There are some countries which don't have separate boards for conducting exams, as such exams are conducted by the ministry such as China, France etc. [28] [29]. However, the objective that each student must take up final examinations at the end of his/her school to qualify for higher education is common across all countries. In our study, we considered evaluating the education board websites for the developed and developing group of countries. Developed countries are countries which have a high quality of life, developed economy, and technological infrastructure [30] [31] . And developing countries have a less developed economy and a comparatively lower quality of life [30] [32]. We have selected the G7 group for developed and BRICS group for

developing countries to evaluate accessibility of education boards websites.

3.1.1 G7 group of countries

The international Group of Seven (G7) is a coalition of seven countries that have the largest and most advanced economies in the world: the United States, Germany, Japan, the United Kingdom, France, Italy, and Canada, along with the European Union. The G7 members represent over 46% of the gross domestic product globally based on nominal values [33], [34]. We have considered exploring education boards for each of the following 7 countries as presented in Table 3:

- *Canada* has multiple school boards based on region [27]. Toronto District School Board is the largest school board in Canada [35]. Thus, we have selected to evaluate accessibility of the Toronto District School Board.
- In *France*, students aged between 11 to 15 years take the DNB (diplôme national du brevet) assessment to receive certification for successful completion of middle school [36] [37]. Students attend the last three years of secondary education and take examination to receive BAC (baccalauréat) certification [36] [37]. The French Ministry of Education issues the respective certification to qualified students. We have evaluated the accessibility of the website of the French Ministry of Education.
- In *Germany*, the highest German school leaving certificate is called "Abitur" [38] [39]. Certification is received by completing 12-13 consecutive schooling years of the Gymnasium and by successfully passing the final school-leaving exam, "Abiturprüfung" [40]. In some states of Germany, such as Bavaria, Abitur is centralized and, in some states, Abitur is conducted at the school level [41]. According to some reports and news, Saxony (one of the federal states of Germany) has the best quality education in terms of student's performance [42] [43]. Thus, we have chosen Saxona curricula website for the accessibility evaluation.
- Maturità is an Italian public high school diploma in *Italy*. To get the Italian public high school diploma, students must pass the Maturità examination. It is a commission examination prepared by the Italian Ministry of Education [44]. Hence, we have evaluated the Maturità website.
- Tokyo Metropolitan Board of Education is the education board followed in *Japan*. The board manages individual school systems within the metropolis and directly addresses all the public high schools in Tokyo [45]. Thus, the website of the Tokyo Metropolitan Board of Education is selected for the accessibility evaluation.
- In the *United Kingdom (UK)*, there are six types of education boards [46] [47] followed in different countries. The AQA (Assessment and Qualifications Alliance) is regarded as the largest exam board in the UK [46] [48]. Therefore, the AQA website is selected for the accessibility evaluation.
- In the *United States (US)*, some states have their state exit examination for students to get a high school diploma certificate after 12th grade [49] [50]. According to reports [37], California, Texas, and Florida have seen a huge number of student enrolment in public high school. However, California does not conduct state exit examinations now. Thus, we have selected to evaluate accessibility for the State Board of Education of Texas which conducts State of Texas Assessments of Academic Readiness (STAAR) for school students (grades 3-12) [51].

Table 3 – Selected education board or equivalent websites of G7 group of countries

Countries	Board name	Website's link
CANADA	Toronto District School Board	https://www.tdsb.on.ca/
FRANCE	French Ministry of Education	https://www.education.gouv.fr/organisation-de-l-ecole-12311
GERMANY	Saxon State Office for Schools and Education	http://lpdb.schule-sachsen.de/lpdb/
ITALY	Ministry of Education	https://www.miur.gov.it/web/guest/home

Countries	Board name	Website's link
JAPAN	Tokyo Metropolitan Board of Education	https://www.kyoiku.metro.tokyo.lg.jp/
UK	AQA (Assessment and Qualifications Alliance)	https://www.aqa.org.uk/
US	State Board Of Education (SBOE)	https://tea.texas.gov/about-tea/leadership/state-board-of-education

3.1.2 BRICS group of countries

BRICS is an acronym for Brazil, Russia, India, China, and South Africa. Goldman Sachs economist Jim O'Neill coined the term BRIC (without South Africa) in 2001, claiming that by 2050 the four BRIC economies would come to dominate the global economy. South Africa was added to the list in 2010 [52], [53]. We have considered exploring education boards for each of the following five countries as listed in Table 4:

- In *Brazil*, students in the last year of high school take the "Enem", a federal government test [54]. The score of Enem helps students to access universities in Brazil. The National Institute of Educational Studies and Research Anísio Teixeira (INEP) is the governing body responsible for conducting various examinations at different levels including Enem. The INEP website provides information related to exams, eligibility, registration and so on. Therefore, we have evaluated the accessibility of the INEP landing page.
- The Unified State Exam in *Russia* is an obligatory exam that serves as both a secondary school final exam and university entrance examination [55]. The Federal Service for Supervision in Education and Science is responsible for conducting such exams [56]. It may be noted that we were unable to access the education-related webpage and so did not evaluate it in the same way.
- In *India*, there are seven types of school boards [26]. To study in higher education, the student must enroll in one of the seven boards. We have evaluated the accessibility of CBSE's academic website. It has a substantial enrolment of students, as well as being considered as the widely acknowledged board in India [57] [58].
- *China* has the Ministry of Education of the People's Republic of China which organizes exams for academic credentials for higher education. Students can find information related to school activities on the respective website [59]. Hence, we have selected the landing page of the Ministry of Education of the People's Republic of China website for the accessibility evaluation.
- *South Africa* conducts "National Senior Certificate" (NSC) examinations annually for grade 12 students. The National Department of Basic Education's website contains information related to curriculum, examination timetables, results, certificates, and so on [60]. We have selected the landing page of the Department of Basic Education to evaluate accessibility.

Table 4 – Selected education board or equivalent websites of BRICS group of countries

Countries	Board name	Website's link
BRAZIL	National Institute of Educational Studies and Research	https://www.gov.br/inep/pt-br
RUSSIA	Federal Service for Supervision in Education and Science	http://government.ru/en/department/35/
INDIA	Central Board of Secondary Education	https://cbseacademic.nic.in/index.html
CHINA	Ministry of Education of the People's Republic of China	http://en.moe.gov.cn/
SOUTH AFRICA	Department of Basic Education	https://www.education.gov.za/Home.aspx

3.2 Selection of web accessibility evaluation tools

Web accessibility evaluation tools are software programs or online services that help to determine if web content meets accessibility guidelines [8]. The World Wide Web Consortium (W3C) provides a list of web accessibility evaluation tools that can be used to evaluate accessibility of any website [8]. In our study, we have considered selecting the tools

based on the set of features by the 'Web Accessibility Initiative' (WAI) [61]. The following features (Fig. 2) were considered to select six accessibility evaluation tools from the W3C website:

1. *WCAG guidelines followed* – each tool is checked if it follows at least one version of the WCAG standards, such as WCAG 2.0 or WCAG 2.1.
2. *Language* – evaluation tools support different languages. We have selected tools that mostly support content in English language.
3. *Type of tool* – evaluation tools can be plugins (extensions) for authoring tools and web browsers, command line tools, desktop or mobile applications, and online services. We have selected tools that are web applications and extensions.
4. *Supported Formats* – the selected tools check accessibility of HTML content and other web technologies, such as WAI-ARIA, CSS, SVG, and PDF.
5. *Assisted by* – some web accessibility evaluation tools can be used in more than one way. We have selected tools that can be used as reports and/or step-by-step evaluation results.
6. *Automatically checks* – the scope of what the evaluation tool can automatically test varies depending on the tool. The tools check a single page or entire groups of related pages.
7. *License* – the tools that are available are open-source /free to use, commercial, enterprise and so on. We have selected tools that are free to use.
8. *Accessibility information* – we have selected tools that are accessible so that people with disabilities can use them.
9. *Success criteria* – there are three levels of conformance defined by W3C [62], level A, level AA and level AAA respectively. Level A is the minimum level to which every website should conform. Level AA is the sufficient level covering requirements of level A and level AA. Level AAA is the highest level of conformance, including all levels A, AA, and AAA. According to W3C, many organizations aim to achieve AA level [63]. Also, Shashank et al [64] noted that Level AA is sufficient to be achieved by the websites. Thus, we have considered the tools that check for at least two levels of conformance, i.e., Level A and Level AA.
10. *POUR factors* – Guidelines and success criteria defined by the W3C are organized around four principles called the POUR factors. These principles lay the foundation necessary for anyone to access and use web content with ease. POUR is the abbreviation of perceivable, operable, understandable and robust [65]. We have selected tools that are checked to follow at least two of the four factors.

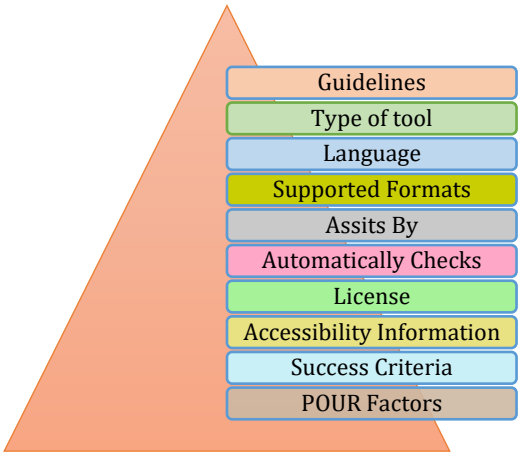

Fig. 2 – Set of selected features for choosing web accessibility evaluation tools

Therefore, we have selected six different web accessibility tools that confirm all parameters considered. The tools are available on the W3C website [8] for the evaluation process and are as follows:

1. *Access Assistant Community Edition by Level Access*

   This tool supports WCAG 2.0 and tests webpages for accessibility instantaneously, within the browser and all iterations of code, including web components. The tools highlight the elements with violations.
   Release date- 15 December 2017
   Link- https://www.webaccessibility.com/

2. *Button Contrast Checker by Aditus*

   This tool checks all buttons and links on the webpage for WCAG 2.1 compliance, in just a click of a button. This tool checks for contrast of the button specifically.
   Release date- 10 September 2019
   Link- https://www.aditus.io/button-contrast-checker/

3. *Siteimprove Accessibility Checker by Siteimprove*

   This tool scans individual webpages and provides a clear explanation of issues and how

to fix those issues as per the A, AA, or AAA level of the WCAG standards. It also can scan restricted or password-protected pages.
Release date- 2 June 2021
Link-https://siteimprove.com/en/core-platform/integrations/browser-extensions/

4. *TAW by CTIC Technology Centre*

   This tool is an automatic online tool to analyze the accessibility of websites supporting WCAG 2.0.
   Release date- 1 February 2000
   Link- https://www.tawdis.net/

5. *Utilitia Validator by Utilitia SP. z O.O*

   This tool scans webpages and checks validity according to guidelines which are provided by the Polish government.
   Release date- 1 January 2011
   Link- https://validator.utilitia.pl/analyses/new

6. *WAVE by WAVE by WebAIM*

   This tool adds icons to a webpage and marks potential accessibility concerns. The errors are marked on an interactive interface provided by the tool and are very easy to comprehend.
   Release date- 1 January 2014
   Link- https://wave.webaim.org/

4. RESULTS

In this section, we present the details of the results captured for accessibility evaluation of all selected education board websites (Section 3) for both developing (BRICS) and developed (G7) groups of countries. We have evaluated the selected webpages of BRICS group with the six selected tools (Section 3) followed by evaluating the selected webpages of G7 group of countries. For each tool, we have listed the following:

a) *Issues Identified:* list of all issues identified by the tool across webpages of all selected countries (first column of Table 5, Table 6, Table 7, and so on).
b) *Most common issue across selected countries:* list of issues that were most commonly found across webpages of all selected countries.
c) *Highest occurrence of the issue:* list of issues that occurred the greatest number of times either for webpages of one or more countries, or webpages of all countries (Fig. 3, Fig. 4, Fig. **5**, and so on).
d) *Countries with maximum identified issues:* list of countries having the maximum number of identified issues (point a).
e) *Alternate suggestions:* Alternate suggestions are laid out for *the most common issue across selected countries* (point b) and *highest occurrence of the issue* (point c).

4.1 BRICS group of countries

4.1.1 Access Assistant Community Edition tool

Summary of results

a) Issues identified: elements without accessible name, common ID attribute in the same domain, missing attributes of DIV and so on, as listed in Table 5.
b) Most common issue across selected countries: elements without accessible name.
c) Highest occurrence of the issue: elements without accessible name (Fig. 3).
d) Countries with maximum identified issues: India
e) Alternate suggestions:

- Elements without accessible name: Accessible names of UI elements help assistive technologies to identify the elements on the webpage [54] [55]. Hence, an accessible name is essential for the UI elements present on the webpage. Accessibility API provides the accessible name property to the elements [55] [56]. Specific rules must be followed while giving accessible names to the elements [57].

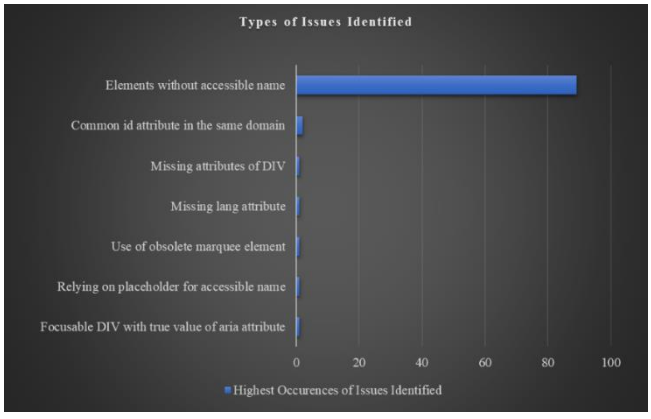

Fig. 3 – Highest occurrence of issues identified for websites selected in BRICS group by Access Assistant Community Edition Tool

Table 5 – Issues identified by Access Assistant Community Edition tool

Identified issues	Brazil	India	China	South Africa
Elements without accessible name	✓	✓	✓	✓
Common id attribute in the same domain		✓		
Missing attributes of DIV	✓			
Use of obsolete marquee element		✓		
Relying on placeholder for accessible name				
Focusable DIV with true value of aria attribute			✓	
No lang attribute		✓		

4.1.2 Button Contrast Checker tool

Summary of results

a) Issues identified: text contrast failure and non-text contrast failure (Table 6).

b) Most common issue across selected countries: text contrast failure.

c) *Highest occurrence of the issue:* text contrast failure (Fig. 4).

d) Countries with maximum identified issues: Brazil, India, and South Africa.

e) Alternate suggestions:

- Text contrast failure: To resolve text contrast failure, small text contrast should be 4.5:1 and 7:1 to pass AA and AAA levels, respectively [66]. Similarly, large text contrast should have a contrast of 3:1 and 4.5:1 to pass AA and AAA levels, respectively [66].

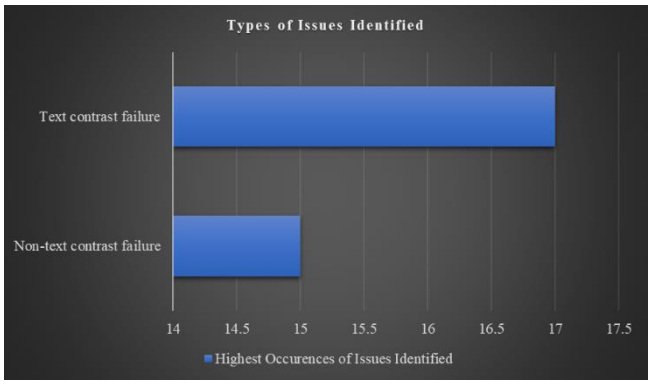

Fig. 4 – Highest occurrence of issues identified for websites selected in BRICS group by Button Contrast Checker tool

Table 6 – Issues identified by Button Contrast Checker tool

Identified issues	Brazil	India	China	South Africa
Text contrast failure	✓	✓	✓	✓
Non-text contrast failure	✓	✓		✓

4.1.3 Siteimprove Accessibility Checker tool

Summary of results

a) Issues identified: link without a text alternative, text not included in an ARIA landmark, line height is below minimum value, unlabeled form field and so on, as listed in Table 7.

b) Most common issue across selected countries: link without a text alternative and line height is below minimum value.

c) Highest occurrence of the issue: text not included in Aria landmark (Fig. 5).

d) Countries with maximum identified issues: India.

e) Alternate suggestions:

- Link without a text alternative*:* Text alternatives describe the purpose of the link [67] [68]. The absence of text alternatives affects the user's motion, cognition, and vision abilities. It fails in the A and AAA levels of conformance. Links represented by images or icons should always have a text alternative.
- Line height is below minimum value: It affects cognition and reading capabilities of the user. It is difficult for users with low vision or cognitive conditions such as dyslexia to read lines of text which are too close together. The paragraph line height should be at least 1.5 times the font size

[69]. This type of issue results in the AAA level of conformance failure.

- Text not included in Aria landmark: It affects the vision ability of the user. Landmark roles provide information about page structure and can help assistive technology users with in-page navigation. Having text outside the landmarks will make navigation more challenging for some visitors [70]. All perceivable text content should be included in an ARIA landmark.

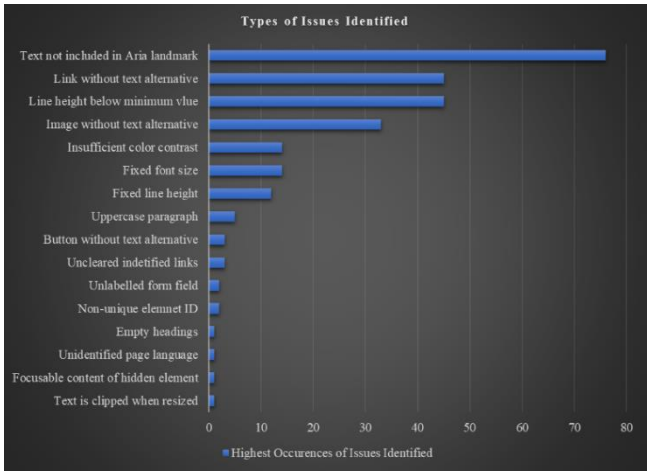

Fig. 5 – Highest occurrence of issues identified for websites selected in BRICS group by Siteimprove Accessibility Checker tool

Table 7 – Issues identified by Siteimprove Accessibility Checker tool

Identified issues	Brazil	India	China	South Africa
Link without a text alternative	✓	✓	✓	✓
Image without a text alternative	✓	✓	✓	
Button without text alternative			✓	✓
Text not included in an ARIA landmark	✓		✓	
Empty headings	✓			
Entire paragraph is in uppercase	✓			
Line height is below minimum value	✓	✓	✓	✓
Unlabeled form field	✓		✓	
Text is clipped when resized	✓			
Element IDs are not unique		✓		
Insufficient color contrast		✓		✓
Fixed font size		✓	✓	
Fixed line height		✓		
Unidentifiable links		✓		
Unidentified page language		✓		
Hidden element has focusable element			✓	

4.1.3 TAW tool

Summary of results

a) Issues identified: Text alternatives: non-text content. Adaptable: info & relationships. Navigable: link purpose (in context). Navigable: link purpose (link only) and so on, as listed in Table 8.

b) Most common issue across selected countries: Text alternatives: non-text content. Adaptable: info & relationships. Navigable: link purpose (in context); and navigable: link purpose (link only).

c) Highest occurrence of the issue: Text alternatives: non-text content (Fig. 6).

d) Countries with maximum identified issues: Brazil and India.

e) Alternate suggestions:

- Text alternatives: Non-text content: It confirms the failure of the perceivable principle and A level of conformance. It is suggested that all non-text content should be accessible through the text alternative [71].
- Adaptable: Info & relationships: It is vital to ensure that the information and relationships of the webpage are preserved whenever the presentation format of the

webpage changes [72]. It helps users who are blind and use screen readers, as well as those who are deaf-blind and using braille.

- Navigable: Link purpose (in context and link only): Link purpose can be defined in two ways, in context and link text only. Link purpose (in context) confirms A conformance level, and link purpose (link only) ensures AAA conformance. The absence of link purpose confirms the failure of the operable principle. The purpose of each link is to be identified from the link text alone [60] or from the link text together with its programmatically determined link context. Providing link text helps users understand each link's purpose so they can decide whether they want to follow the link or not [59].

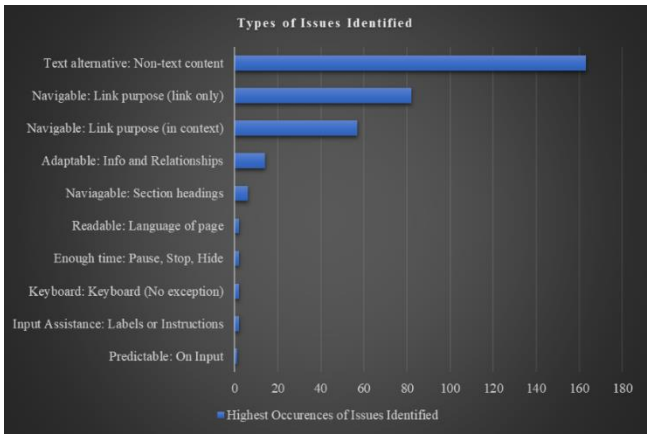

Fig. 6 – Highest occurrence of issues identified for websites selected in BRICS group by TAW tool

Table 8 – Issues identified by TAW tool

Identified issues	Brazil	India	China	South Africa
Text Alternatives : Non-text content	✓	✓	✓	✓
Adaptable: Info & Relationships	✓	✓	✓	✓
Enough Time: Pause, Stop, Hide	✓	✓		
Keyboard: Keyboard (No Exception)	✓	✓		
Navigable: Link Purpose (In Context)	✓	✓	✓	✓
Navigable: Link Purpose (Link Only)	✓	✓	✓	✓
Navigable: Section Headings	✓	✓	✓	✓
Predictable: On Input			✓	
Input Assistance: Labels or Instructions			✓	
Readable: Language of Page	✓	✓	✓	

4.1.4 Utilitia Validator tool

Summary of results

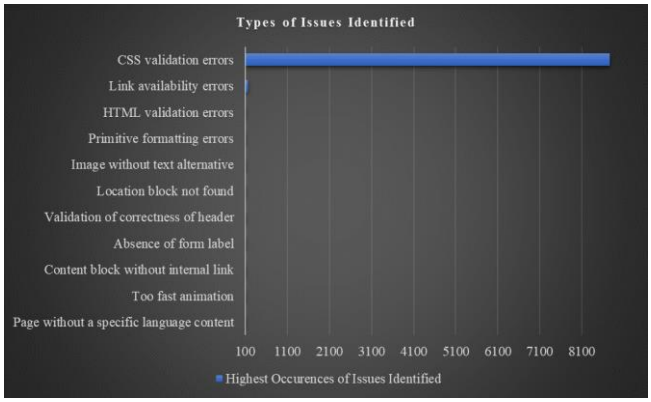

Fig. 7 – Highest occurrence of issues identified for websites selected in BRICS group by Utilitia Validator tool

a) Issues identified: primitive formatting error, blinking items, link availability errors and so on, as listed in Table 9.

b) Most common issue across selected countries: primitive formatting error, and link availability errors.

c) Highest occurrence of the issue: CSS validation errors (Fig. 7).

d) Countries with maximum identified issues: India and China.

e) Alternate suggestions:

- Primitive formatting error: Such errors mainly occur when a paragraph is empty, and it leads to failure of A level success criteria. A paragraph should always be preceded by exactly one blank line, or that paragraph is the first content on the webpage [73]. Also, a paragraph is followed by at least one blank line, or that paragraph

is the last content on the webpage [73]. A paragraph should not contain any blank lines; otherwise, it can lead to primitive formatting errors [73].

- Link availability errors: Such issues mainly exist because of empty links or the link's content is not the same as the other links that lead to the same place [59]. It is advised that link labels should exist and be valid. Otherwise, it fails all the levels of conformance.
- CSS validation errors: Such errors fail A level of conformance. There are multiple causes for CSS validation errors such as non-existence of border-radius, non-existence of zoom property, parse error, etc. To identify the CSS validation error W3C has provided free software named the CSS Validation Service to identify the CSS-related errors on the webpage [74].

Table 9 – Issues identified by Utilitia Validator tool

Identified issues	Brazil	India	China	South Africa
Primitive formatting error	✓	✓	✓	✓
Blinking items		✓		
The presence of form labels			✓	
Validation of the correctness of headers			✓	✓
Correctness of the language declaration		✓		
CSS validation errors	✓			✓
Link availability errors	✓	✓	✓	✓
Presence of media descriptors		✓	✓	
HTML validation errors	✓		✓	
Ability to bypass repetitive blocks error		✓		
The presence of a block informing about the location within the page (crumbs)		✓		✓

4.1.5 WAVE tool

Summary of results

a) *Issues identified:* missing text alternative, linked image missing alternative text, low contrast error and so on, as listed in Table 10.
b) *Most common issue across selected countries:* linked image missing alternative text.
c) Highest occurrence of the issue: low contrast error (Fig. 8).
d) Countries with maximum identified issues: Brazil.
e) Alternate suggestions:

- Linked image missing alternative text: It mainly occurs when an image is without text alternative [75]. This results in an empty link. Because of such an issue, the screen reader is unable to provide any information regarding the link's functionality to the user. It is suggested to add alternative text to the image that presents the image's content and/or links' functionality [76].
- Low contrast error: It mainly occurs when the contrast between the text and the background is not sufficient. It affects users with low vision [77]. It is recommended that text and images of text should have a contrast ratio of at least 4.5:1. Large text should have at least a contrast ratio of at least 3:1 [78].

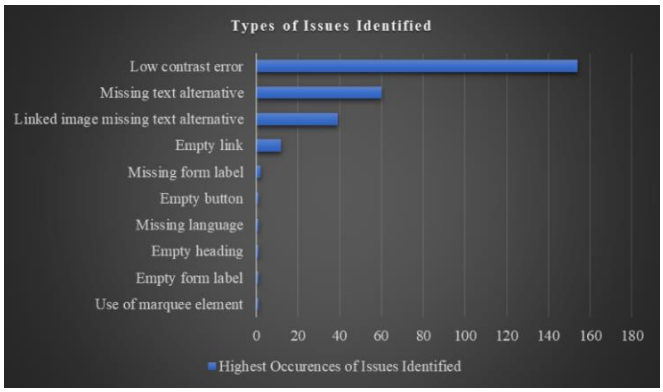

Fig. 8 – Highest occurrence of issues identified for websites selected in BRICS group by WAVE tool

Table 10 – Issues identified By WAVE tool

Identified issues	Brazil	India	China	South Africa
Missing text alternative	✓	✓	✓	
Linked image missing alternative text	✓	✓	✓	✓
Missing form label	✓		✓	
Language missing or invalid		✓		
Empty form label	✓			
Empty heading	✓			
Empty link	✓			✓
Presence of a Marquee element	✓	✓		
Low contrast error		✓		✓
Empty button			✓	
Empty link			✓	

4.2 G7 group of countries

4.2.1 Access Assistant Community Edition tool

Summary of results

a) Issues identified: Invalid or duplicate IDs of Aria-control attribute, Id attribute of 'tab-container' of DIV is not unique in the same DOM, elements without accessible name and so on, as listed in Table 11.

b) Most common issue across selected countries: Each country's website has reported a unique issue, as shown in Table 11.

c) Highest occurrence of the issue: LI (List Item) neither have ol (ordered list) element, ul (unordered list) element nor an element indicating list as a parent (Fig. 8).

d) Countries with maximum identified issues: Canada.

e) Alternate suggestions:

- LI (List Item) neither have an ol (ordered list) element, ul (unordered list) element nor an element indicating list as a parent: It is recommended to always use the ol element or ul element to list the items based on the list's type. It helps some of the assistive technologies to allow users to navigate from list to list or item to item [79]. Also, it helps to group hyperlinks so that screen reader users can bypass the groups of links if they want [79].

4.2.2 Button Contrast Checker tool

Summary of results

a) Issues identified: text contrast failure and non-text contrast failure (Table 12).

b) Most common issue across selected countries: non-text contrast failure.

c) Highest occurrence of the issue: non-text contrast failure (Fig. 10).

d) Countries with maximum identified issues: France, Italy, Japan, and USA.

e) Alternate suggestions:

- Non-text contrast failure: To avoid non-contrast text failure, UI elements should have a contrast of at least 3:1 against adjacent backgrounds [80].

Note: It is observed that the Button Contrast Checker tool was not able to evaluate the accessibility of the UK's selected website.

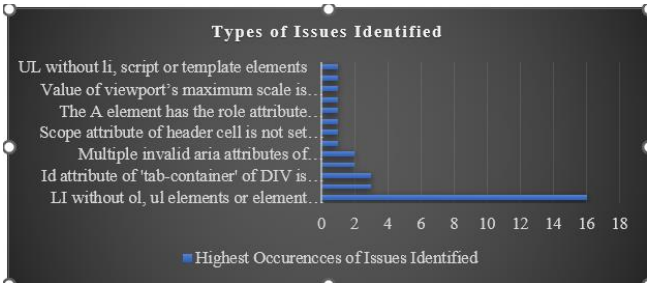

Fig. 9 – Highest occurrence of issues identified for websites selected in G7 group by Access Assistant Community Edition tool

Table 11 – Issues identified by Access Assistant Community Edition tool

Identified issues	Canada	France	Germany	Italy	Japan	UK	USA
Invalid or duplicate IDs of Aria-control attribute of value button	✓						
Id attribute of 'tab-container' of DIV is not unique in the same DOM				✓			
Elements without accessible name	✓						
Scope attribute of header cell is not set to text value	✓						
Multiple invalid aria attributes of SECTION and DIV	✓						
Absence of aria-level attribute in DIV tag							✓
HTML element does not have lang attribute			✓				
The role attribute value of "listitem" is given to the A element				✓			
The A element does not have a mechanism that allows an accessible name value to be calculated					✓		
Value of viewport's maximum scale is set to less than 2					✓		
The A element has the role attribute value of 'navigation'						✓	
LI (List Item) neither have ol (ordered list) element, ul (unordered list) element nor an element indicating list as a parent							✓
The content elements of UL do not have LI elements, script or template elements; or elements with a role=listitem attribute							✓

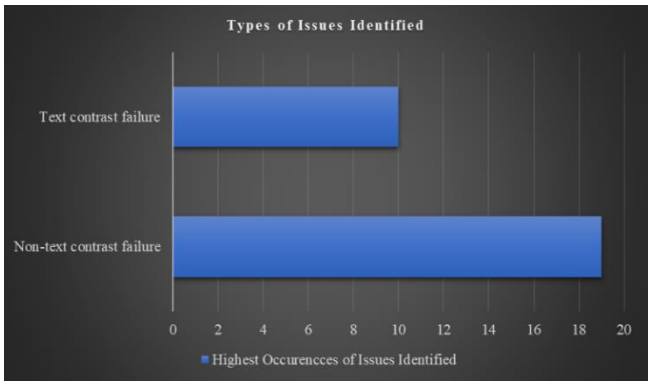

Fig. 10 – Highest occurrence of issues identified for websites selected in G7 group by Button Contrast Checker tool

Table 12 – Issues identified by Button Contrast Checker tool

Identified issues	Canada	France	Germany	Italy	Japan	UK	USA
Text contrast failure		✓		✓	✓		✓
Non-text contrast failure	✓	✓	✓	✓	✓		✓

4.2.3 Siteimprove Accessibility Checker tool

Summary of results

a) *Issues identified:* link without a text alternative, unstructured headings, text not included in an ARIA landmark and so on, as listed in Table 13.
b) *Most common issue across selected countries:* text not included in an ARIA landmark, and line height is below minimum value.
c) *Highest occurrence of the issue:* text not included in an ARIA landmark (Fig. 11).
d) *Countries with maximum identified issues:* Japan.
e) *Alternate suggestions:*
   - Link without a text alternative: text alternatives describe the purpose of the link [67] [68]. The absence of text alternatives affects the user's motion, cognition, and vision abilities. It fails in the A and AAA levels of conformance. Links represented by images or icons should always have a text alternative.
   - Line height is below minimum value: It affects cognition and reading capabilities of the user. It is difficult for users with low vision or cognitive conditions such as dyslexia to read lines of text which are too close together. The paragraph line height should be at least 1.5 times the font size [69]. This type of issue results in the AAA level of conformance failure.

4.2.4 TAW tool

Summary of results

a) *Issues identified:* Text alternatives: non-text content. Adaptable: info & relationships. Navigable: link purpose (link only) and so on, as listed in Table 14.
b) *Most common issue across selected countries:* Navigable: link purpose (link only).
c) *Highest occurrence of the issue:* Navigable: link purpose (link only) (Fig. 12).
d) *Countries with maximum identified issues:* Italy, Japan, and UK.
e) *Alternate suggestions:*
   - Link purpose (link only): It ensures AAA level of conformance. The absence of link purpose confirms the failure of the operable principle. The purpose of each link is to be identified from the link text alone [60]. Providing link text helps users to understand each link's purpose so they can decide whether they want to follow the link or not [59].

Note: It is observed that the TAW tool did not evaluate the accessibility of Canada's selected website.

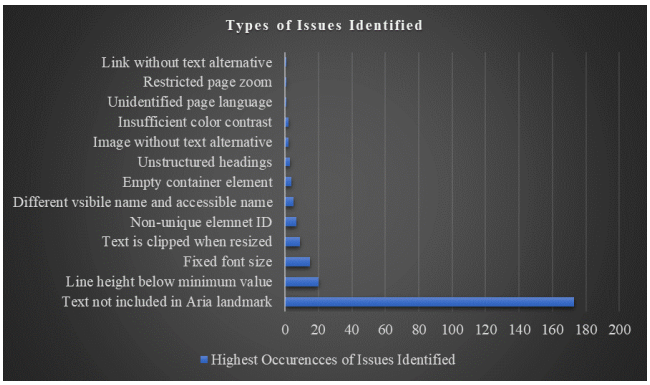

Fig. 11 – Highest occurrence of issues identified for websites selected in G7 group by Siteimprove Accessibility Checker tool

Table 13 – Issues identified by Siteimprove Accessibility Checker tool

Identified issues	Canada	France	Germany	Italy	Japan	UK	USA
Link without a text alternative					✓		
Image without a text alternative					✓		
Unstructured headings						✓	✓
Text not included in an ARIA landmark		✓	✓		✓	✓	
Line height is below minimum value			✓	✓	✓	✓	
Visible label and accessible name do not match				✓			
Required ARIA attribute is missing							✓
Text is clipped when resized				✓	✓		
Element IDs are not unique				✓			
Insufficient color contrast	✓	✓					
Fixed font size							✓

Identified issues	Canada	France	Germany	Italy	Japan	UK	USA
Unidentifiable links							
Unidentified page language			✓				
Skip to main content link is missing						✓	
Container element is empty			✓				✓
Page zoom is restricted					✓		

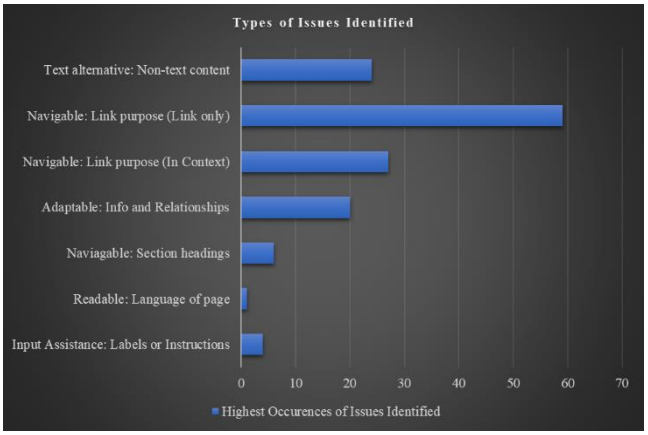

Fig. 12 – Highest occurrence of issues identified for websites selected in G7 group by TAW tool

Table 14 – Issues identified by TAW tool

Identified issues	Canada	France	Germany	Italy	Japan	UK	USA
Text Alternatives: Non-text content				✓	✓	✓	
Adaptable: Info & Relationships				✓	✓		✓
Navigable: Link Purpose (In Context)		✓		✓	✓	✓	
Navigable: Link Purpose (Link Only)		✓	✓	✓	✓	✓	✓
Navigable: Section Headings				✓	✓	✓	
Input Assistance: Labels or Instructions						✓	✓
Readable: Language of Page			✓				

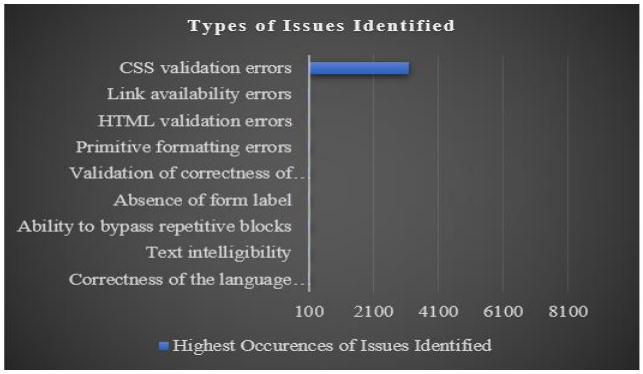

Fig. 13 – Highest occurrence of issues identified for websites selected in G7 group by Utilitia Validator tool

4.2.5 Utilitia Validator tool

Summary of results

a) *Issues identified:* primitive formatting error, CSS validation errors, validation of header correctness and so on, as listed in Table 15.

b) Most common issue across selected countries: CSS validation error and validation of header correctness.

c) Highest occurrence of the issue: CSS validation error (Fig. 13).

d) Countries with maximum identified issues: Canada.

e) Alternate suggestions:

- CSS validation errors: Such errors fail A level of conformance. There are multiple causes for CSS validation errors such as non-existence of border-radius, non-existence of zoom property, parse error, etc. To identify the CSS validation error W3C has provided free software named CSS Validation Service to identify the CSS-related errors on the webpage [74].

- Validation of header correctness: Such type of error fails both A and AAA levels of conformance. It is recommended to use section headings to organize the contents of the webpage [81]. The top-level header should be defined with a h1 tag, and the bottom level header should be defined with a h6 tag [82].

Note: It is observed that the Utilitia Validator tool cannot evaluate the accessibility of Italy's and Japan's selected websites.

4.2.6 WAVE tool

Summary of results

a) Issues identified: missing form label, linked image missing alternative text, empty heading and so on, as listed in Table 16.
b) Most common issue across selected countries: Low contrast error.
c) Highest occurrence of the issue: Low contrast error (Fig. 14).
d) Countries with maximum identified issues: France.
e) Alternate suggestions:

- Low contrast error: It mainly occurs when the contrast between the text and the background is not sufficient. It affects users with low vision [77]. It is recommended that text and images of small text should have a contrast ratio of at least 4.5:1. Large text should have at least a contrast ratio of at least 3:1 [78].

Table 15 – Issues identified by Utilitia Validator tool

Identified issues	Canada	France	Germany	Italy	Japan	UK	USA
Primitive formatting error	✓					✓	
CSS validation errors	✓	✓	✓			✓	✓
Presence of form labels	✓						
Validation of header correctness	✓	✓	✓			✓	✓
Link availability errors	✓	✓				✓	✓
HTML validation errors	✓		✓			✓	
Ability to bypass repetitive blocks error	✓		✓				
Text intelligibility	✓	✓	✓				
Correctness of the language declaration			✓				

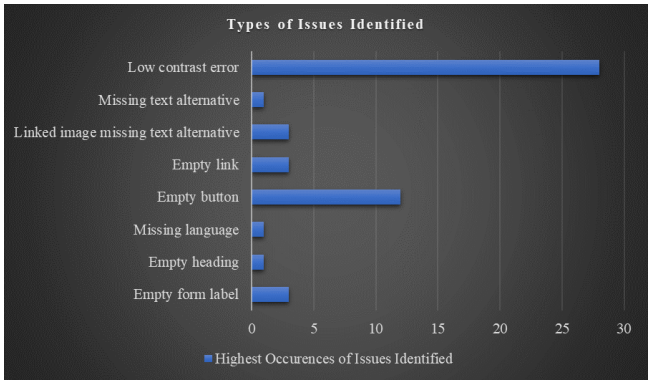

Fig. 14 – Highest occurrence of issues identified for websites selected in G7 group by WAVE tool

Table 16 – Issues identified by WAVE tool

Identified issues	Canada	France	Germany	Italy	Japan	UK	USA
Missing form label	✓					✓	
Linked image missing alternative text		✓			✓		
Empty heading		✓					
Empty button		✓					
Language missing or invalid			✓				
Low contrast error		✓		✓		✓	✓
Missing text alternative					✓		

Identified issues	Canada	France	Germany	Italy	Japan	UK	USA
Empty link					✓		

5. CONCLUSION

This study focuses on identifying accessibility differences in education-related websites of developing (BRICS) and developed (G7) group of countries using six accessibility evaluation tools. Based on the results, we noted that the BRICS group of countries reported the maximum number of accessibility issues when compared to the G7 group of countries (Table 17). Among the group of BRICS countries, the CBSE website of India was identified to have the maximum number of issues by the four tools, namely Access Assistant Community, Siteimprove Accessibility Checker, TAW, and Utilitia Validator (Table 18).

Table 17 – Total number of accessibility issues found in selected BRICS and G7 websites

Tools	Total number of issues identified	
	BRICS	G7
Access Assistant Community Edition	96	34
Button Contrast Checker	32	29
Siteimprove Accessibility Checker	256	243
TAW	331	141
Utilitia Validator	8 982	3 321
WAVE	273	52
Total	**9 970**	**3 820**

Similarly, for the G7 group of countries, the Tokyo Metropolitan Board of Education website of Japan was accounted to have the maximum number of multiple issues reported by two tools, namely Siteimprove Accessibility Checker and TAW (Table 18). Additionally, the selected websites of the BRICS group of countries reported text contrast failure, while the G7 group of countries' websites reported non-text contrast failure. The tools, TAW and Utilitia Validator reported some common issues, namely, Navigable: link purpose (link only), CSS validation error for both BRICS and G7 groups of countries respectively.

Table 18 – Important observations inferred from the accessibility evaluation results

Observations	Countries	Tools
Developing country with the highest number of multiple issues	India	Access Assistant Community, Siteimprove Accessibility Checker, TAW, and Utilitia Validator
Developed country with the highest number of multiple issues	Japan	Siteimprove Accessibility Checker and TAW
Text contrast failure	Brazil, India, China, South Africa	Button Contrast Checker
Non-text contrast failure	Canada, France, Italy, Japan, US	Button Contrast Checker

Overall, from this study, we can infer that education board-related websites for both developing and developed groups of countries lack accessibility in some sense. A similar evaluation can be done in the future, and improvements are suggested for other countries' websites. It is suggested to use more than one accessibility evaluation tool in order to successfully identify and evaluate the accessibility of any website. Further, web developers can consider the alternative suggestions outlined in our study to improve accessibility of the selected websites.

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